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Memorandum

To: Tom Moe

From: Keith Pilgrim

Subject: Tailings Basin Seepage Estimation Method

Date: January 25, 2010

Project: 23/69 1013

An estimate of total average seepage rate for the US Steel Minntac tailings basin was calculated in support of treatability studies currently being conducted by Hatch and in support of seepage collection and water quality monitoring efforts for the Sandy River. This memo serves to document the seepage estimation methodology followed by Barr Engineering.

Tailings Basin Seepage Rate Estimates

- East Side of Basin to Sandy River:
  - Unmonitored seepage = 1255 gallons per minute
  - 030 discharge = 202 gallons per minute
- West Side of Basin to the Dark River:
  - Unmonitored seepage: 1525 gallons per minute
  - 020 discharge = 67 gallons per minute

Estimation Approach and Assumptions

The rate of tailings basin seepage was estimated from the mass of dissolved constituents (sulfate) detected in streams that are downstream of the tailings basin and also collect most if not all of the seepage. Data used to estimate seepage on the eastern side of the tailings basin was taken from the 030 discharge (permitted seepage) monitoring location and the 701 monitoring station that is located on the Sandy River at Highway 53. Data from these locations was derived from discharge monitoring reports (data from 1991 through 2002) and from data collected by Barr Engineering in 2003 and January through March in 2004. Data used to estimate seepage on the western side of the tailings basin was taken from the 020 discharge (permitted seepage) monitoring location and the D-1 monitoring station that is located on the Dark River approximately 2 and ½ miles upstream of Dark Lake.

A general phenomenon observed at the 701 and the D-1 monitoring locations was that high stream flows led to increased delivery of sulfate mass when compared to lower flow conditions (the concentration of sulfate in the streams at these points would not go down during high flows). If tailings basin seep waters were delivered at a constant rate, sulfate levels should have declined at 701 and D-1 at high stream flow rates and increased during lower flows. To explain this observation, it was hypothesized that seepage from the tailings basin (other than seepage from 020 and 030) is stored during low flow conditions and released during medium and high flow events. Wetlands or subsurface soils were hypothesized to be the storage media.

To be able to predict unmonitored seepage (seepage that does not include 020 and 030) delivery to the Sandy and the Dark Rivers during a range of stream flow rates, regression equations were developed between stream flow rate and unmonitored seepage mass delivery. The original intent of this work was to predict tailings basin seepage during low and average stream flow conditions for permitting purposes and this work was not conducted to estimate total tailings basin seepage. To account for changes in tailings basin concentration over time, seepage mass delivery was expressed as "unmonitored seep flow." Using paired measurements of seepage concentration and stream flow and stream concentration, unmonitored seep flow was simply calculated as: **(total mass in the stream per unit time) / (monitored seep concentration)**.

The regression equations described above were then used to estimate the average rate of tailings basin seepage. USGS Stream flow data for the Pike River (the Sandy River turns into the Pike River) and the Dark River were used to estimate flows at D-1 and 701. From the available period of record, seepage for each day was calculated and then all of the estimates were averaged to get an annual average seepage rate. This approach was used to avoid bias (e.g., sampling crews may be less likely to take samples during high and unsafe stream flows or very cold and unsafe conditions when stream flows are low) and to ensure that the stream flow conditions were represented in proportion to occurrence. For the eastern side of the tailings basin, the estimated average seepage rate was 1255 gallons per minute. As a check, the average unmonitored seepage rate calculated from the raw data was 1320 gallons per minute. For the western side of the tailings basin the estimated average seepage rate was 1525 gallons per minute. As a check, the average unmonitored seepage rate calculated from the raw data was 1294 gallons per minute. This difference is likely due to the more limited size of the data set for the Dark River.